

**National Park Service
U.S. Department of the Interior**



**ROCK CREEK PARK
WASHINGTON, DC**

Wireless Telecommunications Analysis Rock Creek Park

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PREFACE

Purpose of the Analysis

The analysis in this report will provide the National Park Service (NPS) with the technical data needed to assist in developing a range of alternatives for the consideration of applications for telecommunications facilities within the boundaries of Rock Creek Park (the park).

The analysis will show:

- The existing service from all licensed service providers individually within the park,
- A composite representation of all service providers combined together, and
- Some technical options the park may use when considering applications for wireless telecommunications facilities.

The following section will describe how the three network deployment methods are designed and planned. For the purpose of this analysis, Enhanced Specialized Mobile Radio (ESMR) operates in the same frequency band as cellular so it will be considered the same as cellular services, and both will be referred to as cellular since the radio frequency (RF) properties are very similar in that band.

Methodology

In developing the methodology for this analysis, the *“Rock Creek Park, Telecommunications Facilities Environmental Assessment”* dated April 2, 2003 and information from National Park Services staff were considered, as well as information gathered during meetings with representatives of all the wireless service providers.

The purpose of this analysis is to provide technical information regarding gaps in wireless telecommunications coverage in and around Rock Creek Park to assist the NPS in developing a reasonable range of alternatives for the National Environmental Policy Act (NEPA) process.

This report will provide the park with background information regarding how the wireless system works and how the service providers develop their networks. Background information will also include the developmental stages of wireless system deployment, the three basic types of wireless services, and the limitations of the systems.

In order to determine where service coverage gaps exist, the methodology included developing a reasonable representation of each of the provider's current service in and around the park. This information was used to produce a composite overlay map of all the current service areas for all providers for the “pedestrian” or “on street” service level. The wireless industry has three defined levels to identify the quality of service. The highest is the in-building services, which translates to a signal power intensity that should allow for consistent and uninterrupted service. Next is the in-car service level, which is a mid-level signal resulting in consistent communications ability. Last, is the pedestrian or street level service representing a level of wireless service the industry finds representative of meeting its minimum service requirement.

This analysis of coverage gaps utilized software common to the wireless industry that computes propagation maps showing signal strength. There is no individual software that is common to all carriers, and each has chosen platforms they feel will best address specific areas and will reflect accurately what may best duplicate actual real-world operating systems. All software has numerous data input requirements that are determined by each particular carrier to generate a predicted service area that will best represent a predicted contour, which best fits their own design standards once the system is in service. Predicted contours can be reasonably confirmed by drive tests. Drive test is a scientifically advanced method used to measure the signal strength and document the system's operation in specific locations by using sophisticated electronic equipment and calibrated antennas. Many times drive tests are conducted where complications require special solutions. Propagation programs are only good if the input data is accurate and is correctly entered. Special attention was afforded to the human aspect of the process, as that is where such inaccuracies would most likely occur. Gathering data is paramount to producing a model that would be within real field test representations. For best accuracy, we used the same input data as provided by the individual carriers when available, as the results should be reflective of each carrier's own computation. Confidentiality agreements were entered into with all but one of the carriers. Three of the carriers provided complete data, and in addition, two of the carriers supplied propagation maps. One carrier provided partial information that was unusable and therefore the specific information was later obtained from other public documents. Comparison of propagation maps from public sources and those that were provided by the carriers, confirmed that the data used for the analysis were accurate, with a high level of confidence in the results.

The analysis combines land-use planning strategies with industry-accepted RF engineering standards to provide technical data to the park during the NEPA process.

CityScape Consultants, Inc.

This analysis was prepared by CityScape Consultants, Inc. (CityScape). CityScape is a land-use planning, legal and radio frequency engineering consulting firm located in Boca Raton, Florida. CityScape specializes in developing land use strategies to control the proliferation of wireless infrastructure, affording the maximum continuing control of local governments, while maintaining compliance with the Telecommunications Act of 1996 and other controlling laws and guidelines.

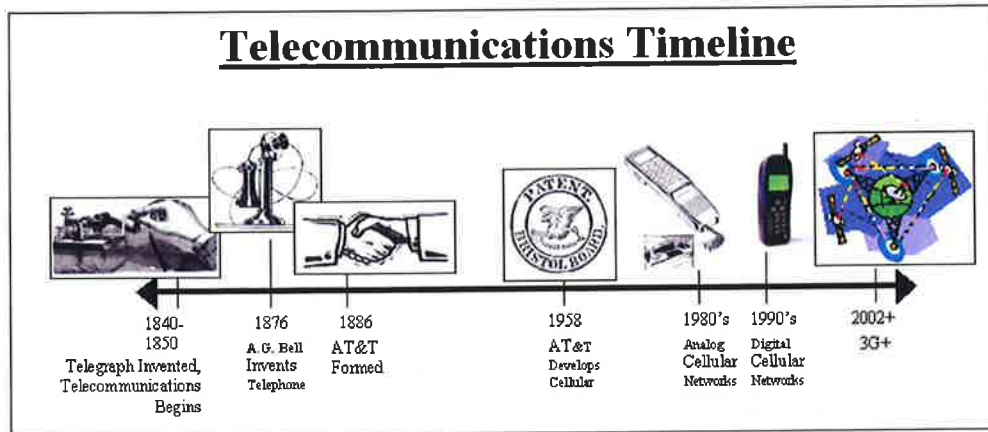


Figure 1: Telecommunication Timeline

B. Wired and Wireless Telephone Networks

When the traditional wired, landline telephone networks were introduced in the United States, the first systems were built in largely populated cities where the financial return on the infrastructure investment could be quickly maximized. Telephone lines were installed alongside electrical power lines to maximize efficiency. As the technology improved the service was expanded from coast to coast. Figure 2 illustrates the wired, landline network system.

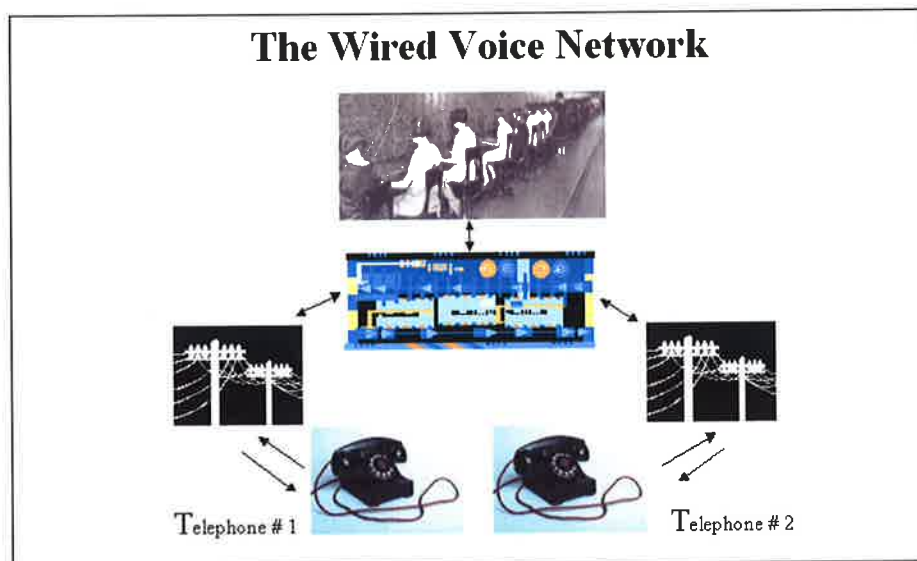


Figure 2: Wired Voice Network Systems

Wireless telephone networks operate utilizing wireless frequencies similar to radio and television stations. To design the wireless networks, radio frequency (RF) engineers overlay hexagonal cells representing circles on a map creating a grid system. These hexagons or circles represent an area equal to the proposed facility coverage area, or the area that a proposed facility would serve. The

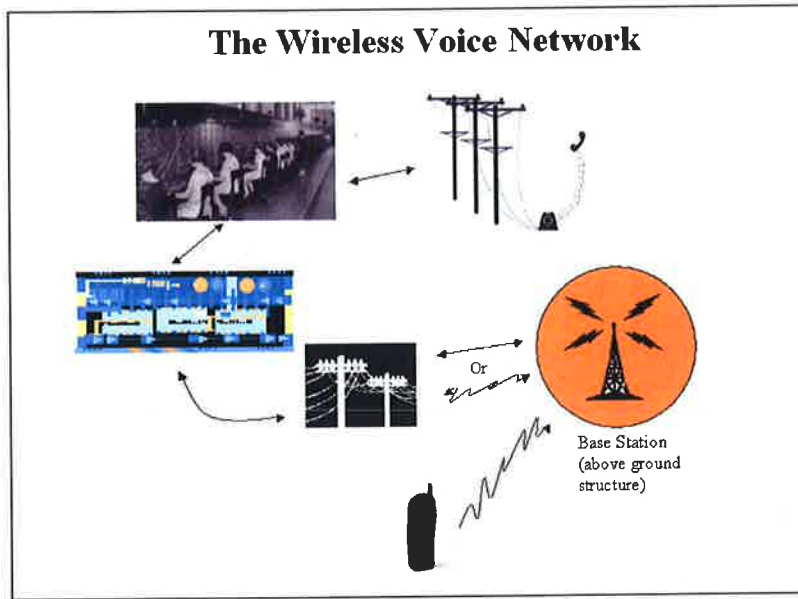


Figure 3: Wireless Voice Network

C. Wireless Providers

In 1983, the Federal Communications Commission (FCC) granted licenses to two competing wireless providers to provide cellular coverage nationwide. The early stages primarily were served by the local telephone companies and on a national level by companies like Cellular One. There were many initial problems and growth was slow. Most wireless providers preferred tall towers in the range of 300 to 500 feet to service large areas. There was also a preference for analog services to reach farther, without much concern for static. Due to the difficulty of constructing new facilities, the expansion was costly and challenging.

In 1995 and 1996, the FCC auctioned four additional licenses in regional areas to competing wireless providers for purposes of building a nationwide digital wireless communication system. This auction raised over twenty-three billion dollars for the United States Treasury, which helped the federal government pay off the annual deficit by 1998.

D. Wireless Coverage

Wireless system providers attain service coverage via antennas located on elevated base stations. The height and location of the towers is critical to meeting the objectives of RF engineering. The systems need continuous coverage with minimal overlap to provide continuous service that the wireless subscribers desire.

In wireless system evolution, a wireless provider initially built fewer base stations with relatively tall antenna-supporting structures to maximize the network coverage footprint. These initial 1G 800 and 900 MHz systems sought to broadcast coverage to large geographic areas with minimal infrastructure. Typically, these tall towers were spaced four to eight miles apart.

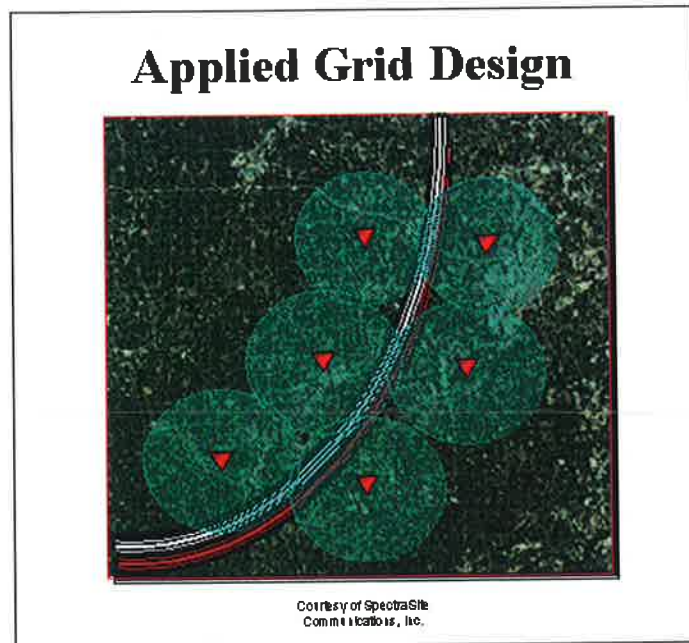


Figure 5: Applied Grid Design

E. Network Capacity

The number of base station sites in a grid network not only determines the limits of geographic coverage, but the number of subscribers (customers) the system can support at any given time. Each base station can process as many as 1,000 subscribers per minute as subscriber's transverse through particular cell sites, yet at any time a single cell site can handle simultaneously no more than 200 calls (different providers prefer different numbers, 1,000 is an average). This process is referred to as network capacity. As population and wireless customers increase, excessive demand is put on the existing system's network capacity. When the network capacity reaches its limit, a customer will frequently hear a rapid busy signal, get a message indicating all circuits are busy, or commonly be asked to leave a message without hearing the phone ring on the receiving end of the call.

As the wireless network reaches design network capacity, it causes the coverage area to shrink, further complicating coverage objectives. Network capacity can be increased several ways. The service provider can readjust the antennas to better serve the needed area, or the provider can add additional base stations with additional infrastructure.

A capacity base station has provisions for additional calling resources that enhance the network's ability to serve more wireless phone customers within a specific geographic as its primary objective. An assumption behind the capacity base station concept is that an area already has sufficient radio signals from existing coverage base stations, and the signals are clear. But there are too many calls being sent through the existing base stations resulting in over-capacity or busy messages, leading to no service indications for subscribers when they press the call send button on the wireless handset.

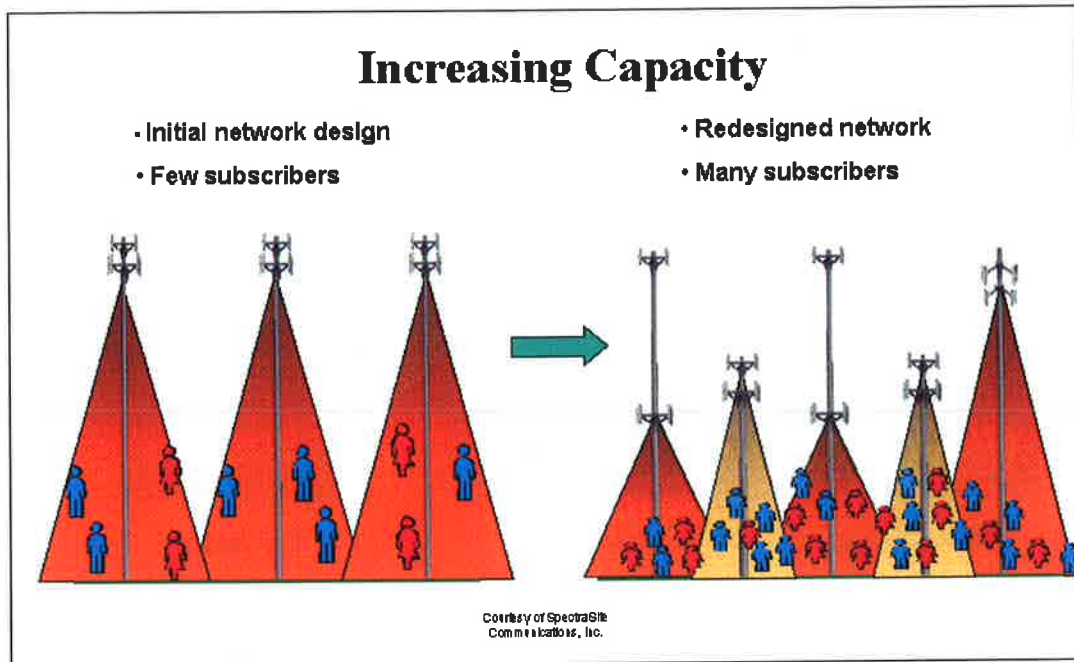


Figure 7: Increasing Network Capacities

F. Wireless Infrastructure and Zoning

Wireless base stations are facilities for mounting antenna arrays, for the purpose of meeting wireless telecommunication network deployment plans. A variety of structures can be used as base stations, such as towers, buildings, water tanks, existing emergency communications system tower facilities, tall signage, and light poles. Use of these structures is dependent on: 1) the structure being structurally capable of supporting the antenna and the inter-connecting coaxial cables and, 2) sufficient ground space to accommodate the accessory equipment cabinets used in running the network. Base stations can also be camouflaged in some circumstances to visually blend in with the surrounding area.

Figure 8 shows examples of some typical base stations. The monopole is a freestanding pole similar to an oversized utility pole. The lattice tower is also a freestanding, tripod shaped tower, with crisscrossing brackets. The guyed tower is not a freestanding tower and relies on the attached cables and anchors to support the facility. The flagpole is a camouflaged tower. The antennas are flush-mounted onto a monopole and a fiberglass cylinder is fitted over the antenna concealing them from view. The bell tower is a camouflaged lattice tower. The antennas are hidden above the bells and behind the artwork at the top of the structure.

The location of the antenna is critical to attaining an optimum functioning network. With the deployment of 1G, there were only two competing wireless cellular providers. But with the deployment of 2G the wireless market place became furiously competitive. “Speed to market” and “location, location, location” became the slogans for the competing 1G and 2G providers. The initial strategy was for service providers to operate a single base station only for their needs. The concept of sharing base stations was not part of the strategy as each provider sought to have the fastest deployment, so as to develop the largest customer base, resulting in a quick return on their cost of deployment. This resulted in an extraneous amount of new tower construction without the benefit of local land use management.

Coincidentally, as governments began to adopt development standards for the wireless communications industry, the industry strategy changed again. The cost associated with each provider developing an autonomous inventory of base stations put a financial strain on their ability to deploy their networks. As a result, most of the wireless providers divested their internal real estate departments and tower inventories. This change gave birth to a new industry, vertical real estate, including a consortium of tower builders, tower owners, site acquisition and site management firms. No longer was a tower being built for an individual wireless service provider, but for a multitude of potential new tenants who would share the facility without the individual cost of building, owning and maintaining the facility. Sharing antenna space on the tower between wireless providers is called co-location.

This industry change should have benefited local governments who adopted new tower ordinances requiring co-location as a way to reduce the number of new towers. But, it did not because the vertical real estate business model for new towers was founded on tall tower structures intended to support as many wireless providers as possible. As a result, local landscapes became dotted with all types of towers and communities began to adopt regulations to prohibit or have the effect of prohibiting wireless communication towers within their jurisdictional boundaries.

Wireless deployment came to a halt in many geographical areas as all involved in wireless deployment became equally frustrated with the situation such as the large sum of money paid by the 2G wireless providers for the rights to provide wireless services, the license agreements between the wireless providers and the FCC mandated the networks be deployed within a specific time period, and the prohibition of facility deployment through new zoning standards by local government agencies were prohibiting the deployments through new zoning standards. This perplexing situation prompted the adoption of Section 704 of the Federal Telecommunication Act of 1996.

G. Exposure to Radio Frequency Emissions

Exposure to RF emissions is one concern associated with the siting of telecommunications facilities. The FCC has rules for human exposure to electromagnetic radiation. Electromagnetic radiation should not be confused with ionizing radiation, the differences of which are described below.

Ionizing radiation is radiation that has sufficient energy to remove electrons from atoms. This type of radiation can be found from many sources, including health care facilities, research institutions, nuclear reactors and their support facilities, nuclear weapon production facilities, and other various manufacturing settings, just to name a few. Some high-voltage beam-control devices, such as high-power transmitter tubes can emit ionizing radiation, but this is usually

4. Re-position antennas such that people cannot get in close proximity to them.

In multi-transmitter facilities, it is necessary to evaluate each contributor individually. Its percent of RF emissions is computed (or measured), and added together to sum all percentage figures to determine the total site exposure.

2. PHONES

In July 2001, the Federal Drug Administration (FDA) issued a Consumer Update on Wireless Phones, which stated that "[t]he available scientific evidence does not show that any health problems are associated with using wireless phones," while noting that "[t]here is no proof, however, that wireless phones are absolutely safe."

The FCC issued a Consumer Information Bureau Publication in July 2001, which stated, "[t]here is no scientific evidence to date that proves that wireless phone usage can lead to cancer or other adverse health effects, like headaches, dizziness, elevated blood pressure, or memory loss."

Before a wireless phone model is available for sale to the public, it must be tested by the manufacturer and certified to the FCC that it does not exceed limits established by the FCC.

One of these limits is expressed as Specific Absorption Rate (SAR). SAR is a measure of the rate of absorption of RF energy in the body. Since 1996, the FCC has required that the SAR of handheld wireless phones not exceed 1.6 watts per kilogram, averaged over one gram of tissue.

Steps that can be taken to minimize RF exposure from cell phones include:

1. reduce your talk time,
2. place more distance between your body and the source of the RF, and
3. in a vehicle, use a phone with an antenna on the outside of the vehicle.

The FDA stated in reports that, "[t]he scientific evidence does not show a danger to users of wireless phones, including children and teenagers." People who wish to reduce their RF exposure may choose to restrict their wireless phone use.

H. Emerging Technologies

At the onset of this millennium economists and telecommunication forecasters debated the actuality of third, fourth, and fifth generations of wireless coming to fruition in the United States. Skepticism that customers would have little demand for the emerging wireless services appeared in articles and newsrooms, while others recognized the infrastructure in the United States was significantly behind schedule as compared to the European and Asian deployments. It was predicted that consumers would demand the 3G products once theoretical plans were instituted through technological advancements. This third generation deployment requires advanced handset and base station updates and due to that has progressed slower when compared to the 1G, or initial briefcase analogue phones and 2G, or digital deployments, but systems are being tested, designed, built and instituted.

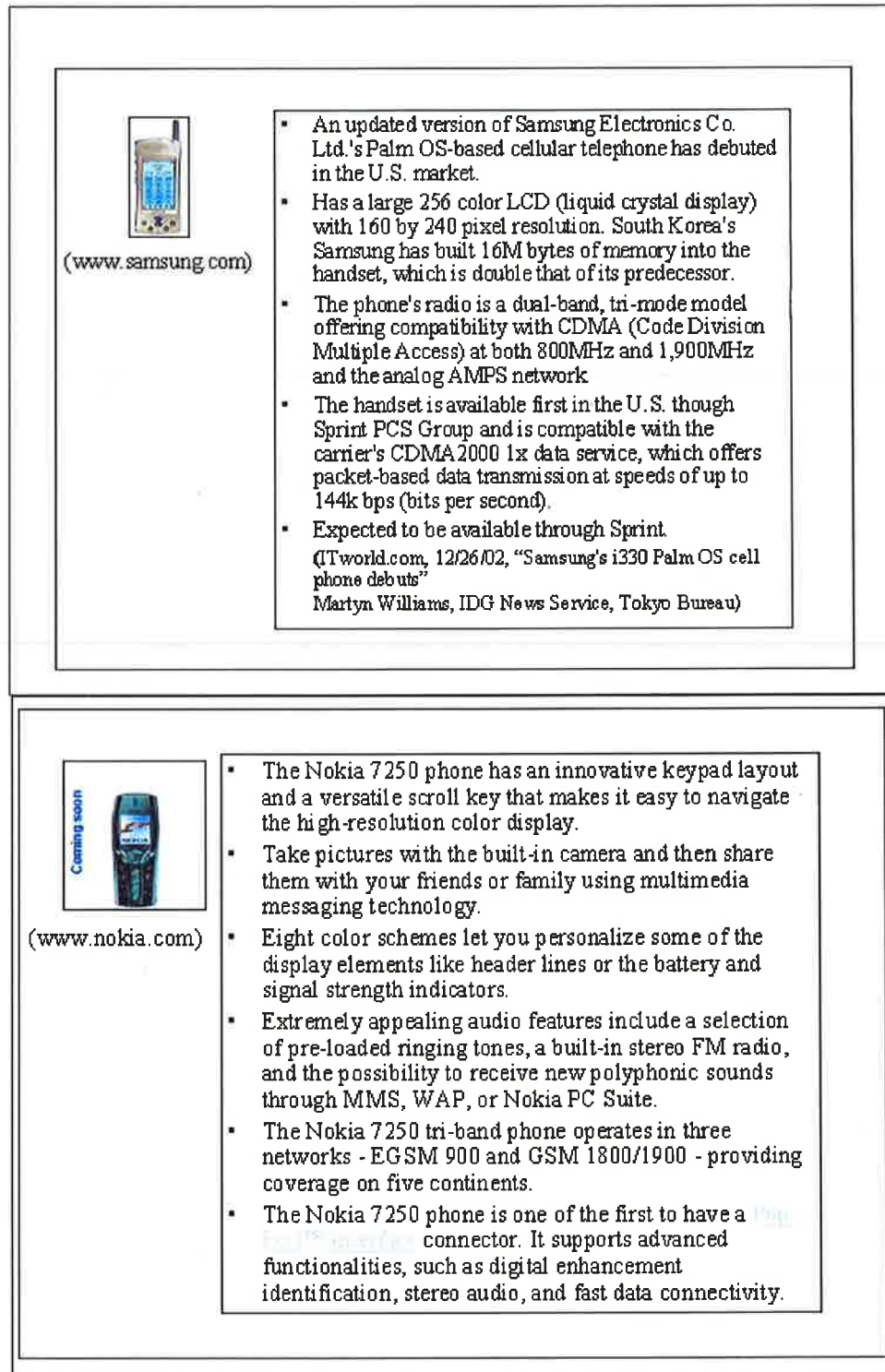


Figure 9: 3G Wireless Phones and Related Services

4. PREPARATIONS FOR 3G INFRASTRUCTURE

The phasing out of analog compatibility requirements for cellular phones by the year 2008 has been approved by the FCC, although the Commission's action still allows providers the option to continue analog services as needed to meet customer needs. According to the Cellular Telecommunications & Internet Association (CTIA) about 95 percent of all wireless subscribers are already using digital technology, and wireless users generally replace their phones every eighteen months. Thus, the phase out period should be ample time to migrate the remaining analog users to digital. The carriers support this migration because conversion to all digital has the added benefit of increasing cell site capacity, as a single analogue channel can be converted to three to four digital channels. One of the reasons for delaying is the automotive industry's use of automobile communication services such as "On-Star."

For a long period of time text messaging was limited to only customers of the same provider; therefore, the need for additional facilities was not a substantial requirement. The CTIA recently announced wireless carriers are now participating in a program that allows a customer of one carrier to communicate through text messaging with a customer of another carrier, again creating more demand to facilities. One of its many benefits is as an electronic alternative to a postage stamp, allowing the customer to send text messages from anywhere and that can be delivered anywhere at anytime. Text messaging has been proven to very successful in other countries. In Australia, a recent Coca-Cola promotion resulted in over seven million text messages over a span of thirteen weeks. In Europe, one company quit issuing paychecks to its employees and instead now sends employees a text message confirming that the funds have been deposited.

At the turn of the century there were one billion messages sent a day globally. Every digital phone that is sold today in the United States has messaging capability. In Europe last year, 15 percent of the carriers' revenue came from text messaging. The growth of text messaging in the United States will undoubtedly lead to a greater demand for wireless facilities because the additional spectrum use by text messages will create a system capacity demand for providers. Third, fourth and fifth generations of wireless deployment will bring the next phases of wireless technology and place great demands on network capacity. With voice, text, and data all competing for spectrum space, providers will need to maximize their spectrum allocations by creating more compact base station facilities at closer intervals.

5. EMERGING TECHNOLOGIES

Wireless providers are presently deploying new technology equipment in the United States to support data services over the wireless interface. One such example of this type of deployment has been a Global System for Mobile Communications (GSM) overlay on top of existing facilities, in recognition of the GSM data-handling capability. This is a service used internationally and allows customers to use services worldwide. In certain cases, the GSM overlay is on 1900 MHz, where signals only cover about half the distance of the existing system, implying more wireless facility locations will be required to meet coverage and network capacity objectives.

"Most people see the cell as the blue hexagon, being defined by the tower in the center, with the antennas pointing in the directions indicated by the arrows. In reality, the cell is the **red hexagon**; with the towers at the corners...the confusion comes from not realizing that a cell is a geographic area, not a point."

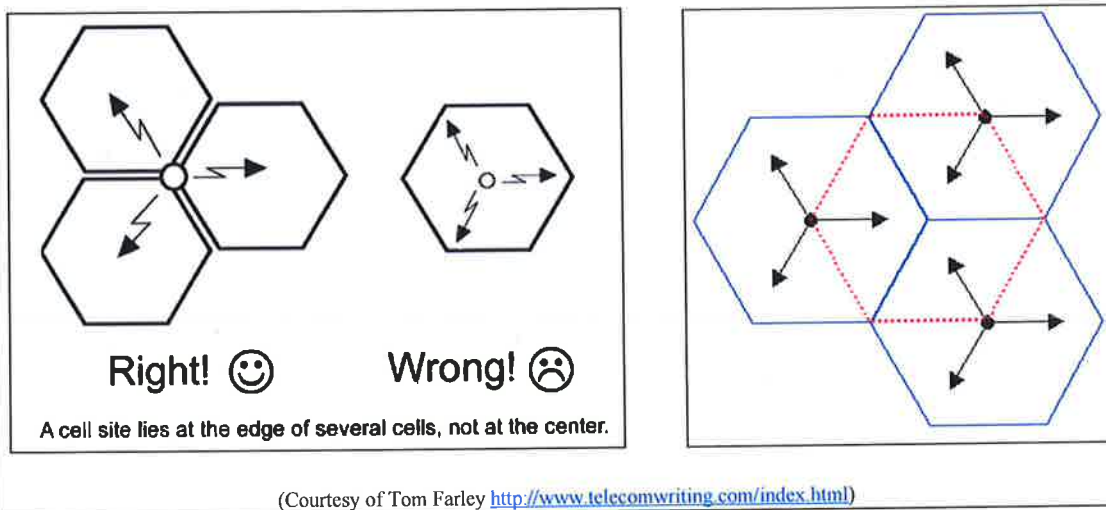


Figure 10: Network Grid

B. Search Area within Proposed Coverage Areas

The search area for new wireless infrastructure is ideally specified in a document provided to site search consultants by the provider in pursuit of a lease for property on which to place their facilities, whether a new tower, a rooftop or some other existing structure that could accommodate wireless antennas. From an engineering perspective, any location within the proposed search area is considered to be acceptable for the provider, with certain considerations based on terrain and sometimes population balance.

C. Search Area Radii

Search areas for the 800 MHz (cellular and ESMR) frequencies and 1900 MHz (PCS) frequencies are computed in the tables below. The tables utilize the "Okumura-Hata" propagation path loss formula for 800 MHz, and the "COST-231" formula for 1900 MHz. Using the tables in Figure 11, maximum coverage radii for typical in-vehicle coverage is calculated for various tower heights. All computations have mathematic formulas to account for the various operational requirements, all intended to provide a certain level of service and smooth transition between cell base stations.

III. ENGINEERING GUIDELINES FOR THE GAP ANALYSIS AT ROCK CREEK PARK

A. Analysis Design Process

This analysis evaluates Rock Creek Park wireless telecommunications coverage gaps and the infrastructure required to address those gaps, and is accomplished by:

1. Researching the inventory of existing antenna-supporting structures and buildings in the vicinity of the park. Projection of the existing service utilizing only these facilities (Figure 13).
2. Identifying areas within the park that have a certain level of cellular and PCS coverage, including terrain information and existing wireless support structures to determine the existing as-built conditions.
3. Providing an engineering analysis of existing coverage based on the inventory of facilities in and around the park, and regulatory height restrictions.

B. Park Property and Existing Antenna Locations

The analysis of coverage gaps started with a base map of the park, including all 99 administered units. It was determined and then confirmed by the carriers that the only section of the park in which additional support structures were needed is with Reservation 339, its tributaries, and the Rock Creek and Potomac Parkway (referred to as the main section of the park). Existing facilities that surround the park were then added onto the map (Figure 14). In the vicinity of the main section of the park, there are currently 54 wireless telecommunications facilities. Of these 54 facilities, 2 tower facilities, pictured below in Figure 12, are located within the park boundary and the remaining facilities are around the perimeter of the park. In Washington D.C., existing buildings are overwhelmingly used for facilities rather than towers, due to land availability and local zoning restrictions.

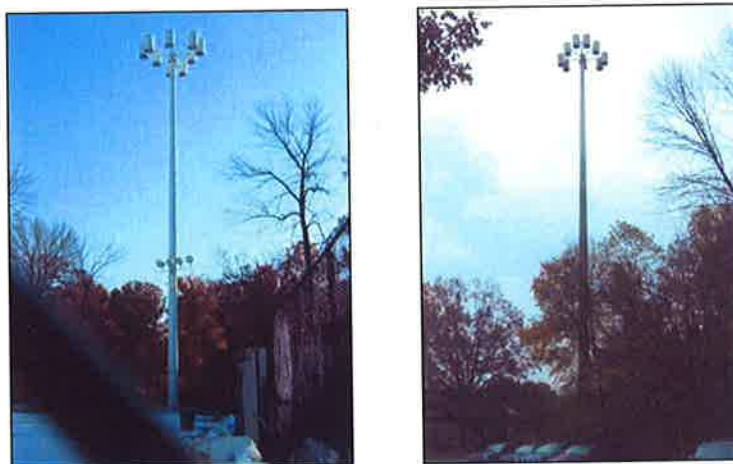


Figure 12: Existing Park Facilities

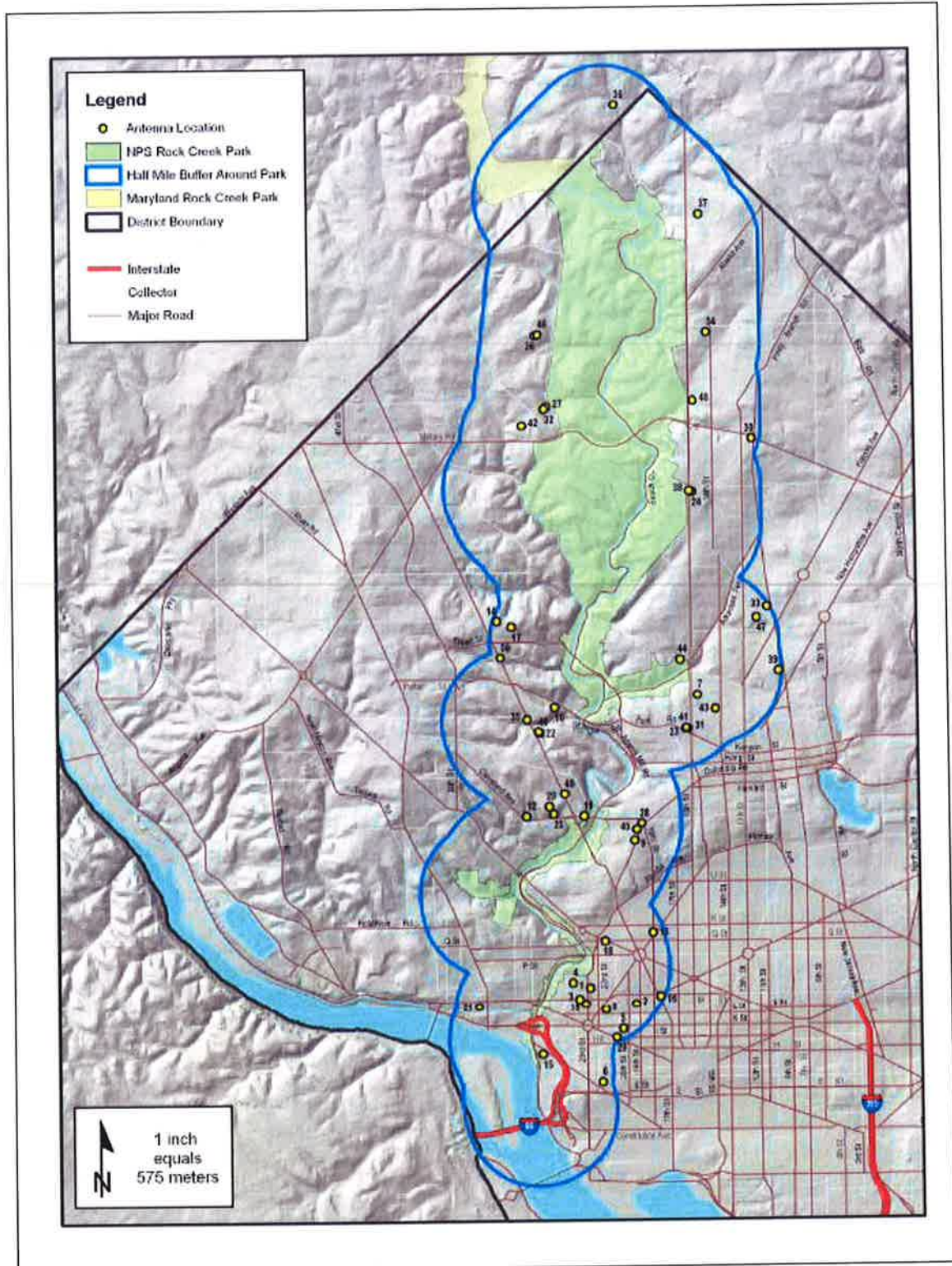


Figure 14: Main Park Section (including existing facilities)

coverage without considerations of population or topographic variables could be obtained with only two sites. Population and terrain of specific geographical areas and the total number of minutes used by the wireless subscribers within that designated area can have significant affects on the circumference of the coverage area.

Referring to the 1900 MHz “COST-231” formula coverage as shown in Figure 15, a reasonable coverage area for an antenna for a PCS site on flat terrain is 1.64 miles. Figure 17 shows the theoretical need for only three sites located within Rock Creek Park jurisdictional boundaries. These sites represent a theoretical build out of 80 foot antenna locations at equal dispersion for one cellular provider again with no consideration of adjacent community wireless deployment, no terrain or population considerations, and assuming no suitable existing structures are available.

Figure 17 further illustrates the hand-off radius applicable to 1900 MHz from three above ground antenna locations within Rock Creek Park, demonstrating that initial PCS coverage without considerations of population and topographic variables would be almost 100 percent complete. The hand-off radius for 1900 MHz is reduced because of the difference in PCS operating frequencies and technologies as compared to the 800 MHz frequency.

800 MHz						
Antenna Height	35'	50'	80'	100'	115'	150'
Radius, miles	2.14	2.53	3.20	3.60	3.88	4.50
Allow for handoff, miles	1.71	2.03	2.56	2.88	3.10	3.60
Search Area, miles	0.43	0.51	0.64	0.72	0.78	0.90

1900 MHz						
Antenna Height	35'	50'	80'	100'	115'	150'
Radius, miles	1.15	1.33	1.64	1.82	1.96	2.23
Allow for handoff, miles	0.92	1.07	1.31	1.46	1.56	1.79
Search Area, miles	0.23	0.27	0.33	0.36	0.39	0.45

Figure 15: 800 and 1900 MHz Coverage Tables

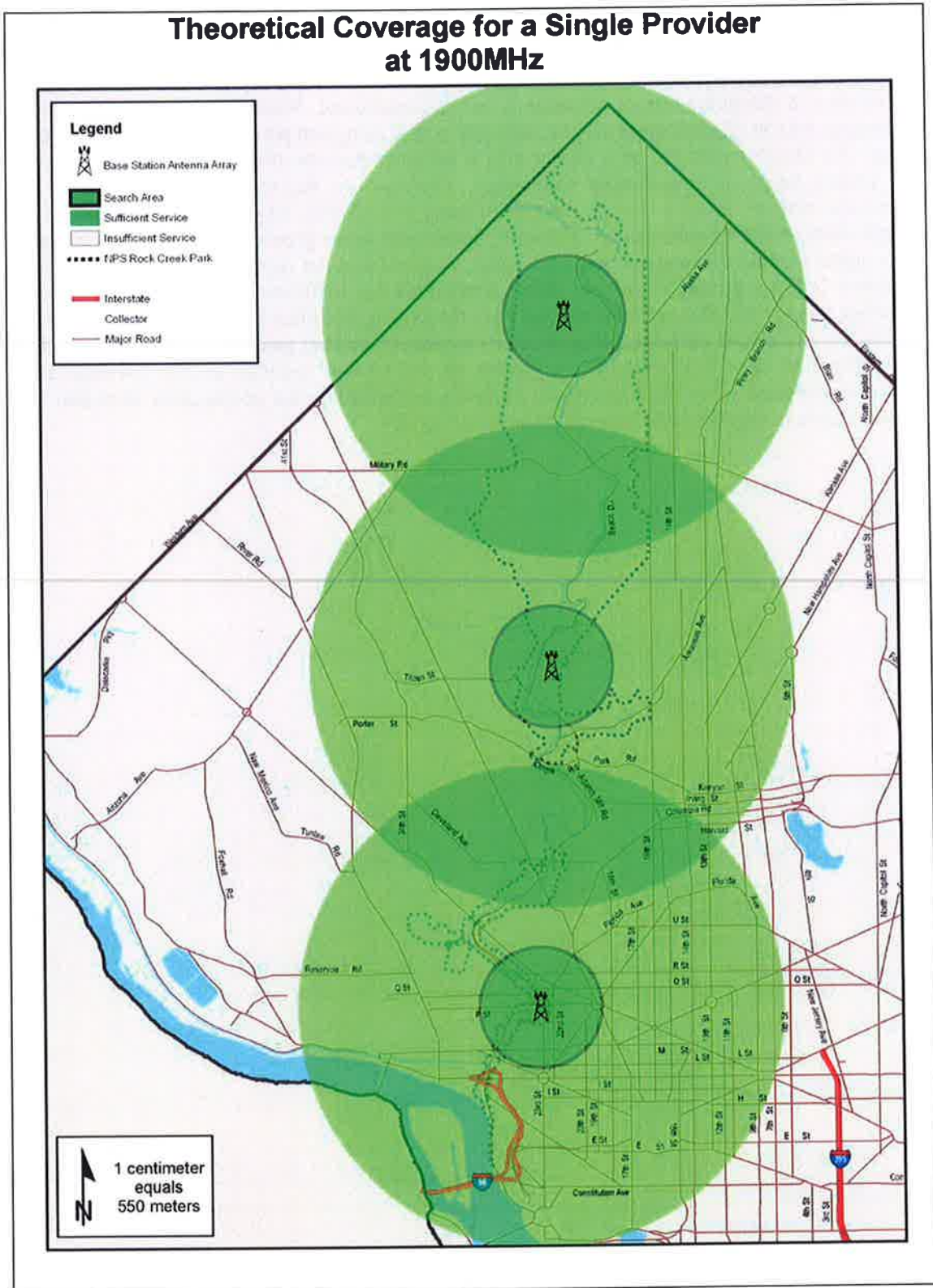


Figure 17: Theoretical Flat Terrain Service for 1900 MHz

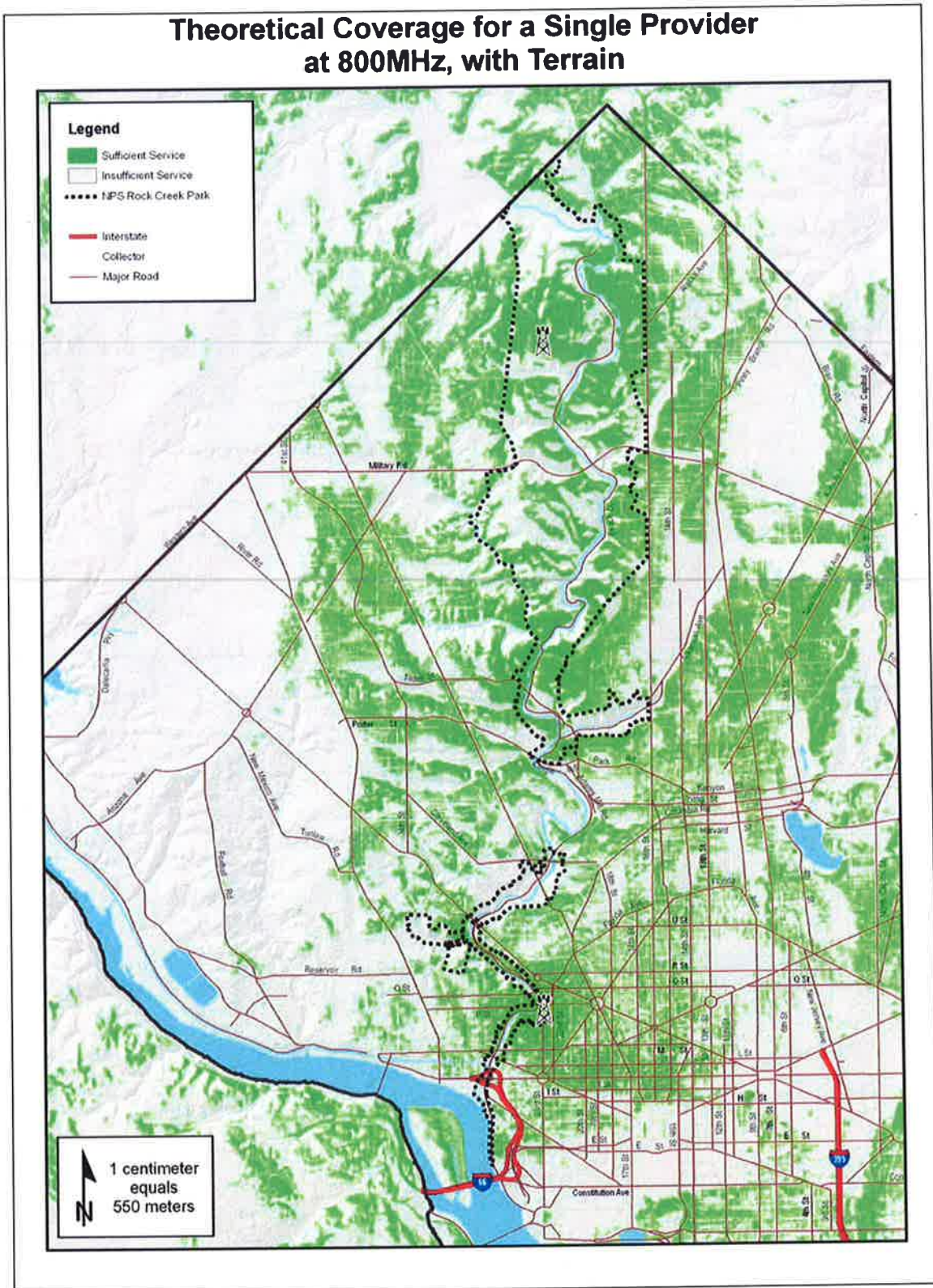


Figure 18: 800 MHz Theoretical Coverage with the addition of terrain features

F. Effects of Topography on Coverage

Most of the park area has challenging topography, resulting in issues related to the abrupt changes in the ground level when considering wireless telecommunication service. Wireless services operate generally in line-of-sight methods. Radio frequencies in these bands travel in straight lines, so any obstructions in the signal path will cause a signal change, normally a reduction or complete loss of signal. In addition, natural vegetation affects wireless services, resulting in different levels of service during different times of the year. This is caused by the loss of leaves from trees and even the moisture content of the vegetation which all impact the line-of-sight. As part of this analysis, once a range of alternatives has been developed by the NPS, an analysis will be prepared to confirm the various alternatives with propagation maps that will consider the varying seasons, showing three levels of services for each carrier within the park, including in-building, mobile, and pedestrian.

Providing service inside park buildings from locations outside the boundaries of the park would be virtually impossible, mostly due to the terrain. As the following analysis details, addressing coverage gaps within the park along the creek bed and Beach Drive is not feasible from solely outside the park due to terrain. For example, park terrain has varying ground elevations. This demonstrates why new or improved facilities located outside the park do not provide a solution to the coverage gaps. The terrain within the park has elevations doubling, both higher and lower, in short distances in many areas. In some places, the park ground elevation can vary as much as 300 feet in very short distances, sometimes as short as a city block. This is the fundamental problem carriers have in achieving service into the park as shown below in Figure 20.

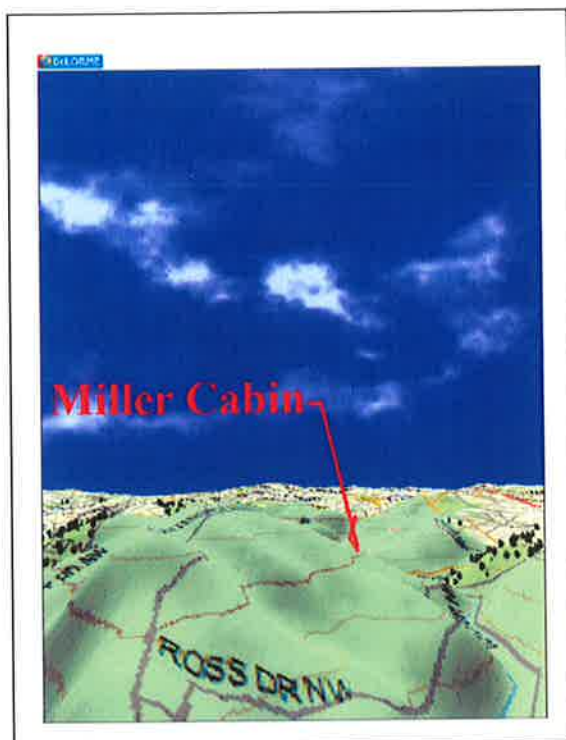


Figure 20: Park Topography

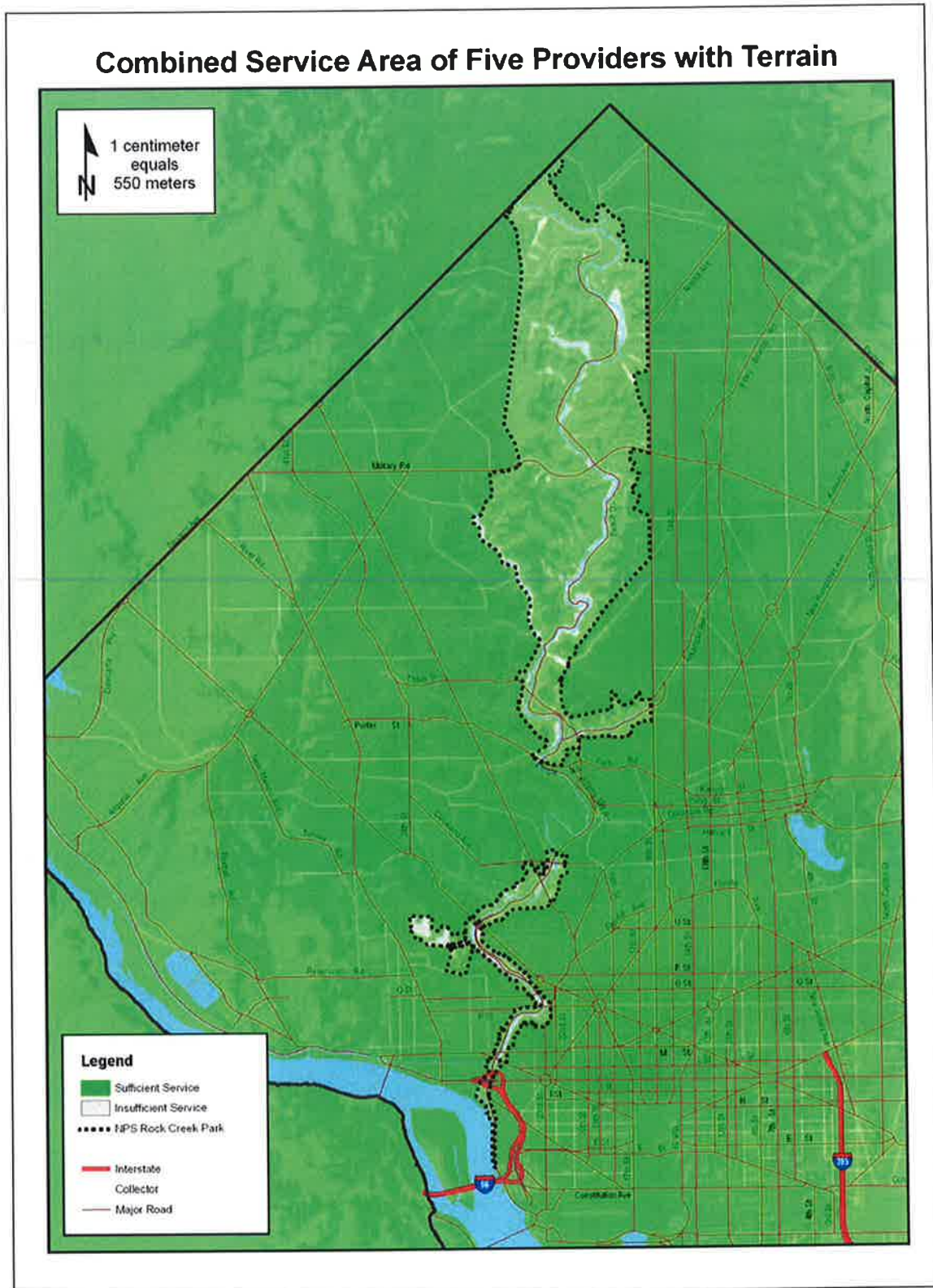


Figure 21: Composite Service Area

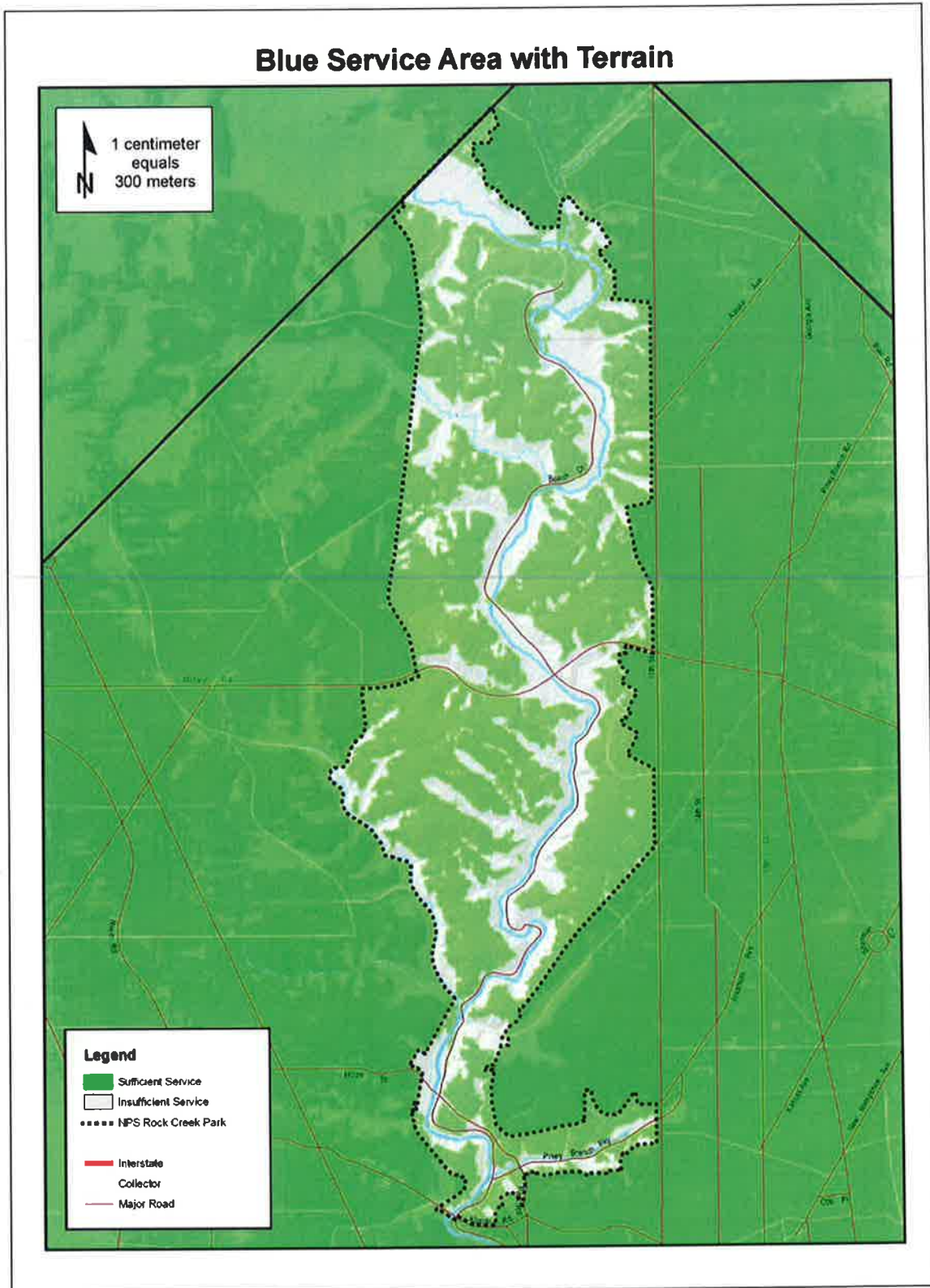


Figure 23: North Blue Carrier Service Area

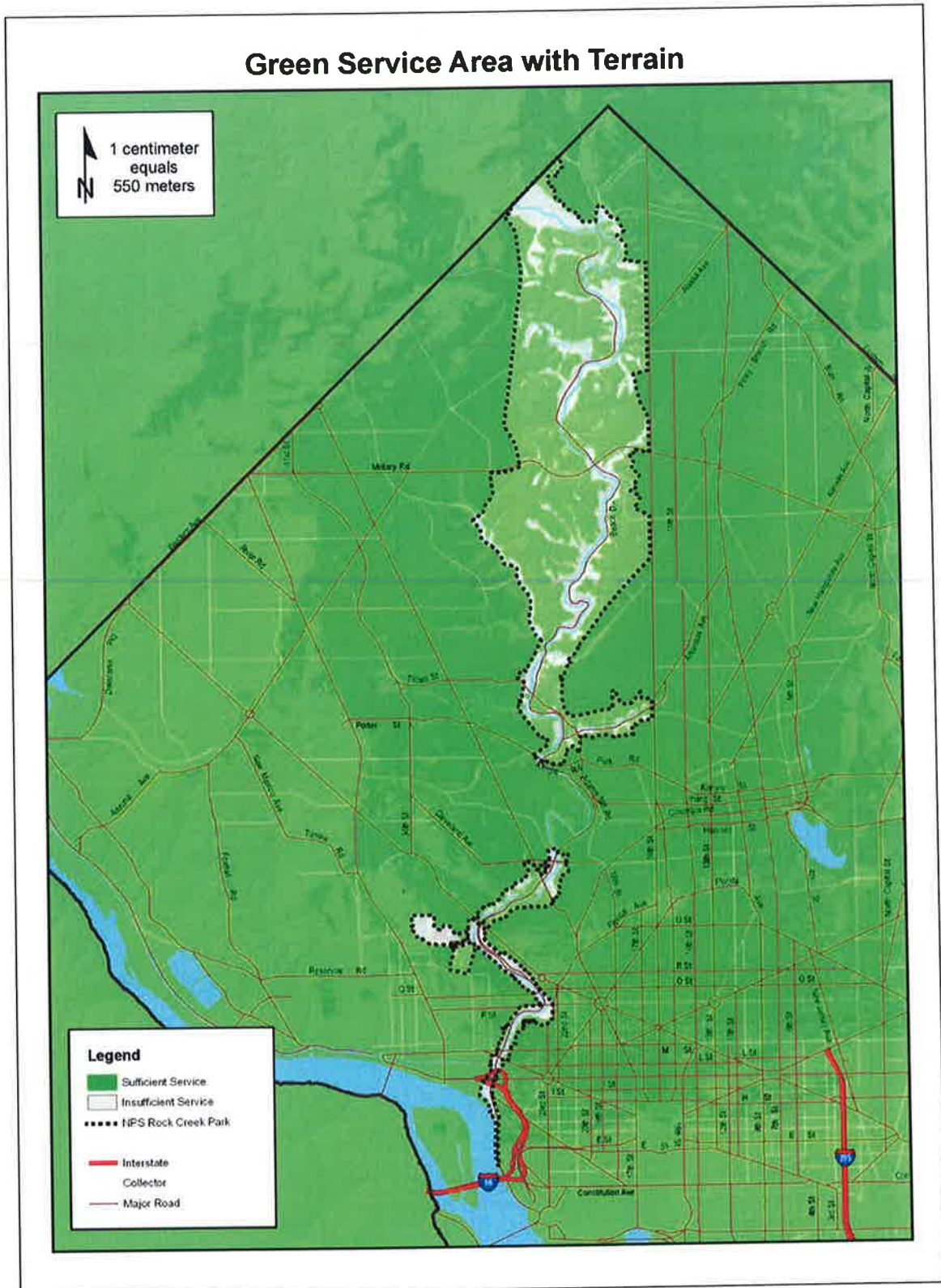


Figure 25: Green Carrier Service Area

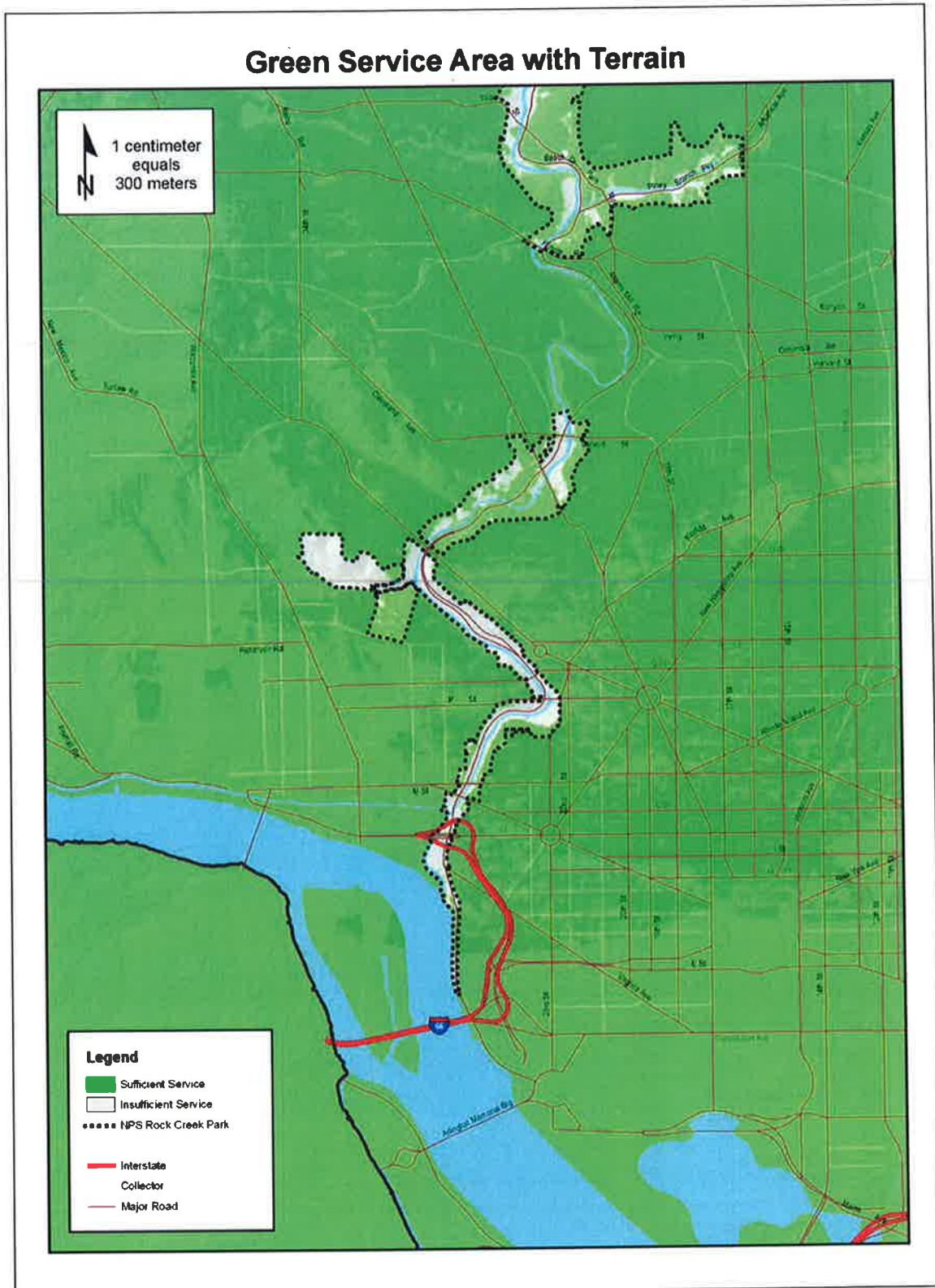


Figure 27: South Green Carrier Service Area

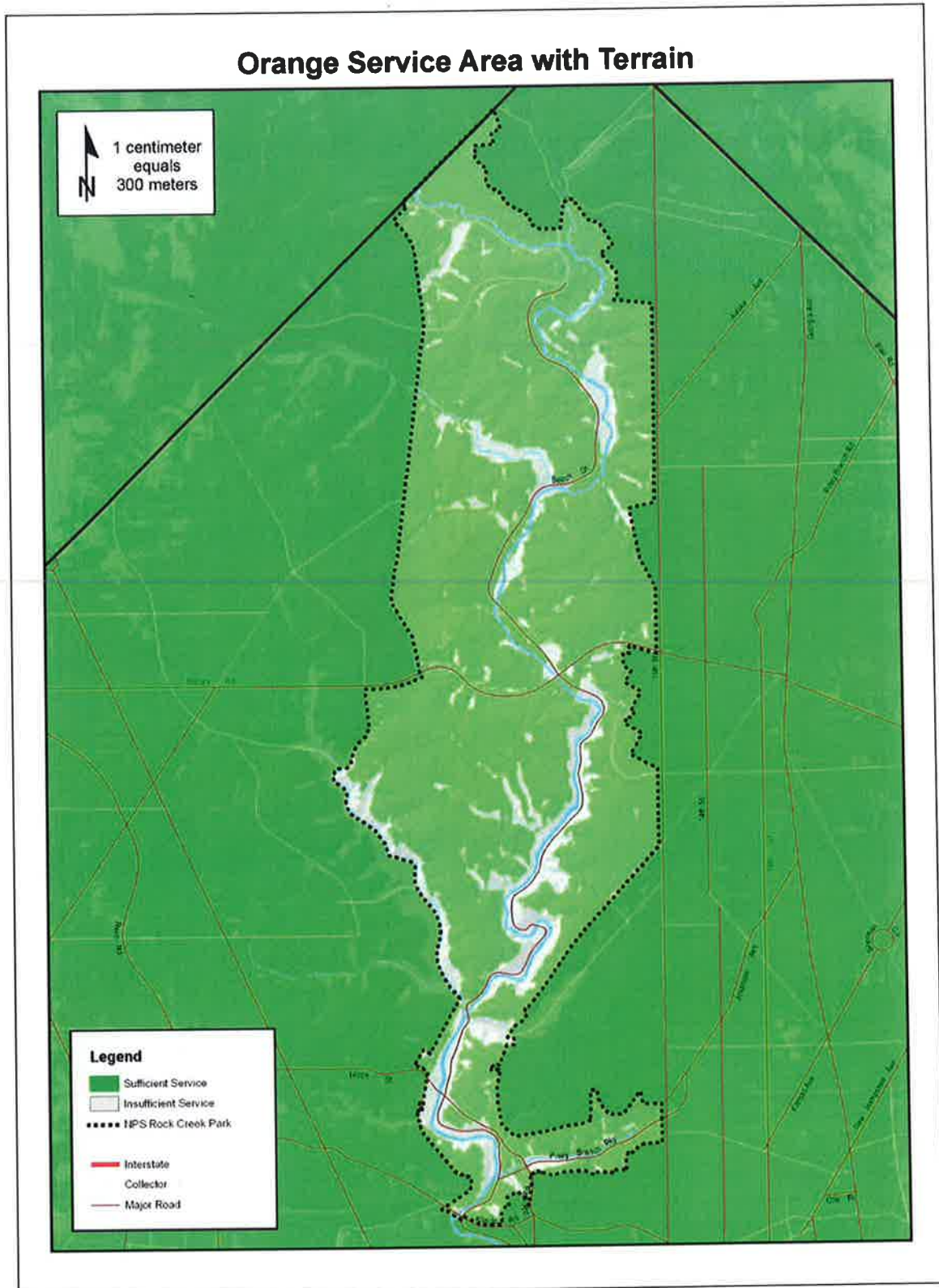


Figure 29: North Orange Carrier Service Area

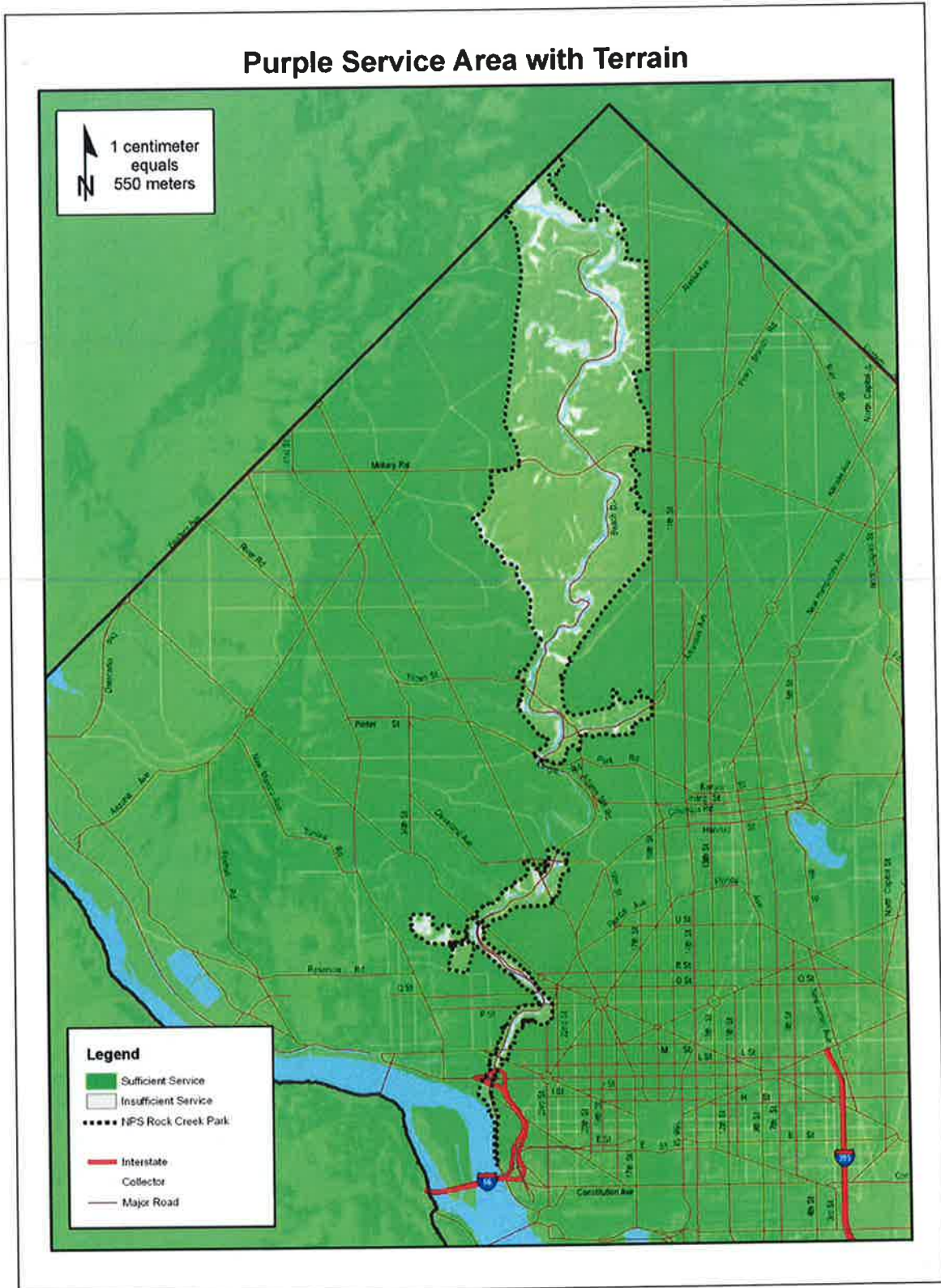


Figure 31: Purple Carrier Service Area

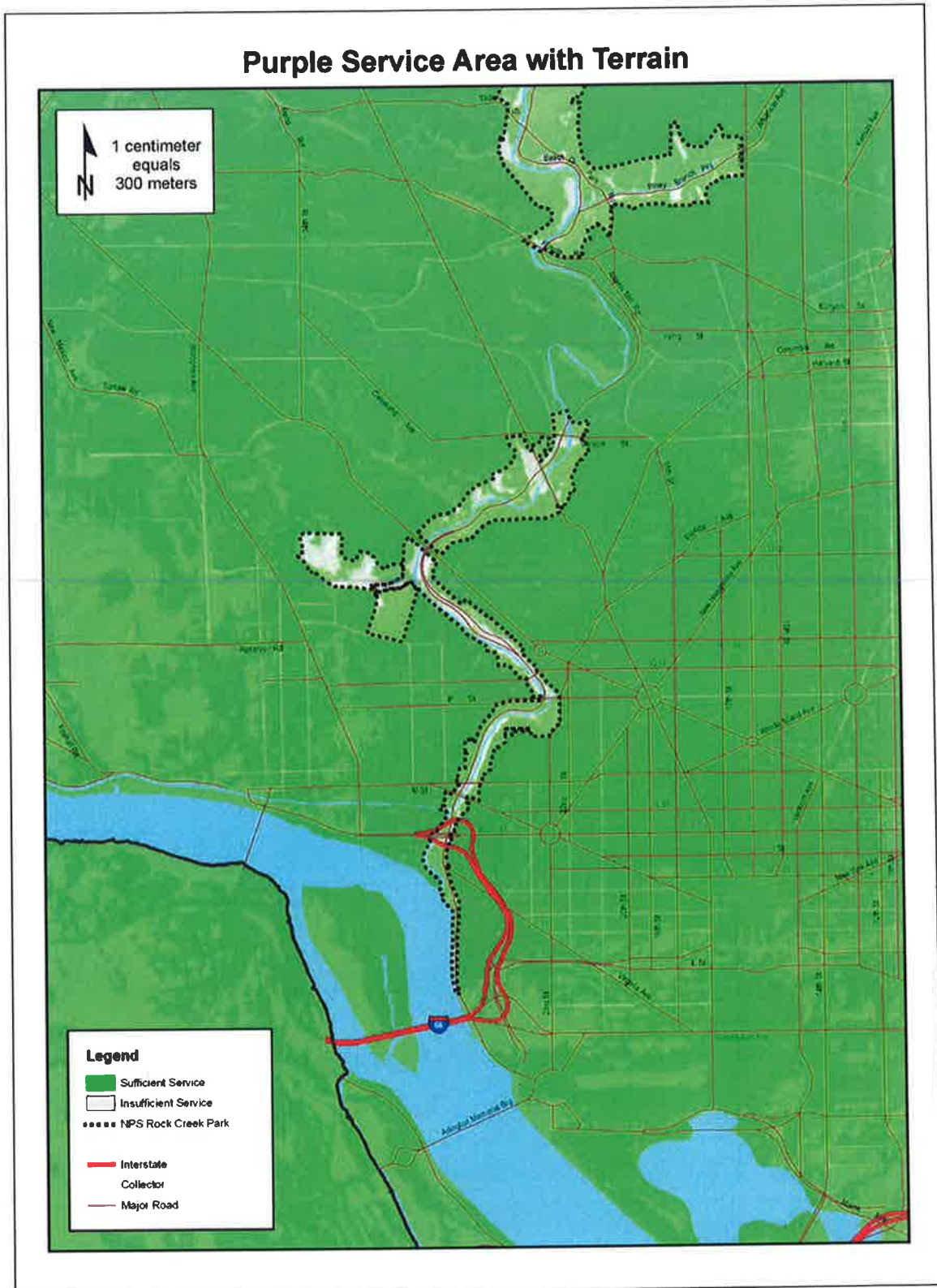


Figure 33: South Purple Carrier Service Area

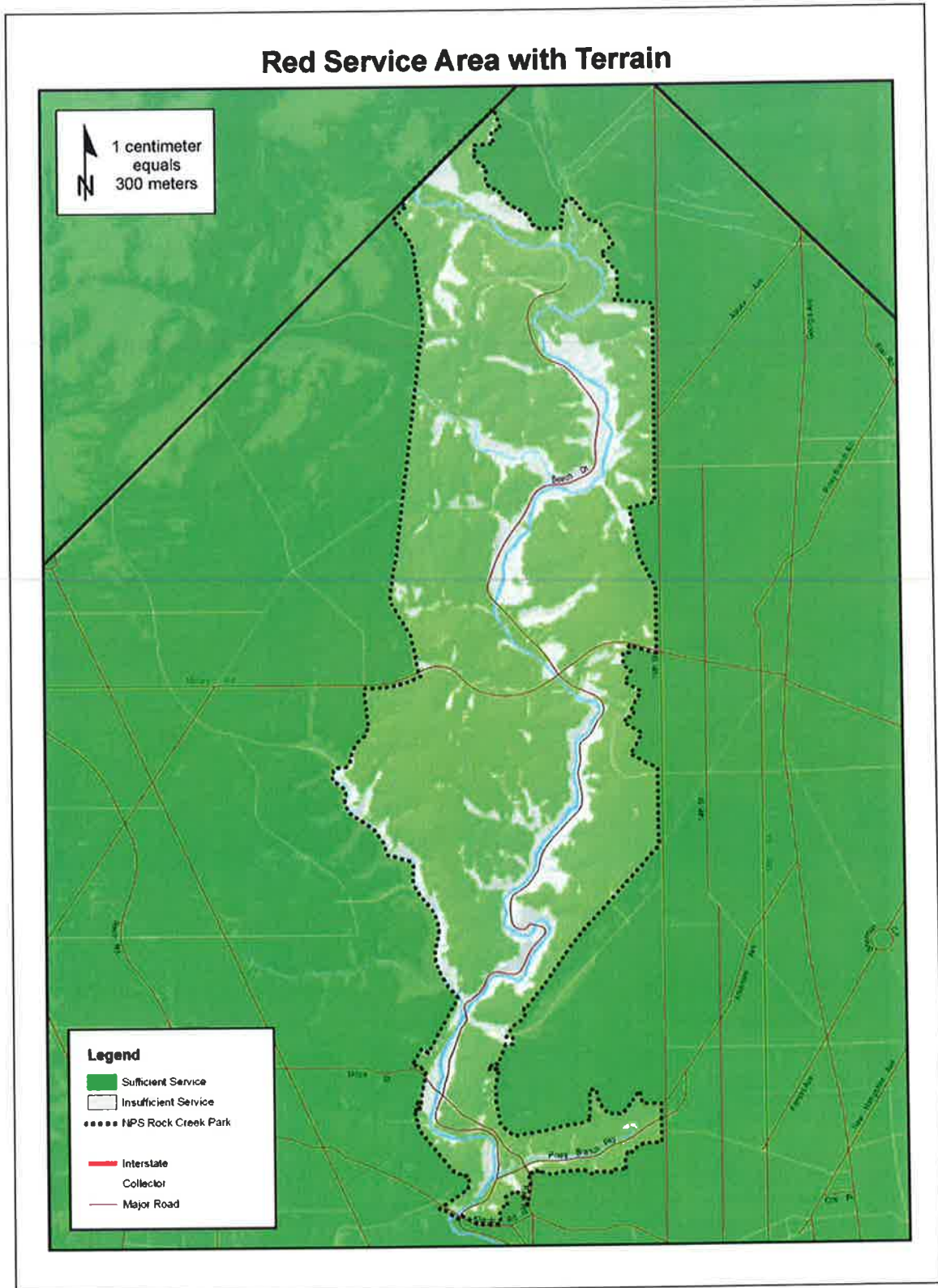


Figure 35: North Red Carrier Service Area

IV. SITING CONSIDERATIONS

A. Future Siting Considerations

When looking at developing wireless telecommunication facilities, it is important to note the history of siting these facilities. Historically wireless service providers have developed their networks individually and on an as-needed basis. This ad hoc method has resulted in a non-uniform development of infrastructure, with each carrier only addressing their particular needs. This is normal and not either illegal or inappropriate, allowing the provider a speed to market. Once a sensitive area is defined, a carrier has interest in rectifying the problem as quickly as they can and having to coordinate with other carriers could slow the process. In addition, from a competitive standpoint sometimes cooperation will work against the individual carrier's success. In recent years there has been more cooperation between carriers, including, but not limited to, communications between carriers of interest in developing sites at the outset of planning.

As part of this analysis, interviews were conducted with firms related to the wireless service providers to explore options that could assist the park in developing alternatives. As the analysis showed, most of the areas that were considered by the interviewees as problematic were in the deep crevices of the creek bed and it was determined that this could not practically be addressed from outside the park boundaries alone, as discussed in Section III. Some technical considerations to consider when addressing coverage gaps in Rock Creek Park include:

- locate facilities directly in the area with no signal, inside park boundaries,
- use a combination of facilities inside and outside the park boundary,
- locate away from the general public on park property, such as at the maintenance yard,
- place concealed facilities along the ridgelines within the wooded areas, all outside of public traffic and view, and/or
- use a combination of facilities in the wood line, and others directly along Beach Drive.

A proposal was presented to the Park by Crown Castle to develop facilities along Beach Drive (Figures 37, 38, and 39). This approach would directly address the known signal void areas, but would require further study to determine an optimum height of each support structure and a reasonable assumption of how many would be needed. Further exploration of this proposal would occur within the context of the alternatives development for the wireless telecommunication facility plan/EA that is currently being prepared. During discussions with providers, the idea of a private infrastructure development, such as Distributive Antenna Systems (DAS), scenario was discussed and all carriers voiced concerns that over pricing would be an issue.

1. ESTABLISHMENT OF A HIERARCHY

The following shows a hierarchy demonstrating a typical order of siting preference. This is for demonstration only, as a hierarchy would be the sole decision of the park. This example is provided to demonstrate how some municipalities/others have approached telecommunications siting plans.

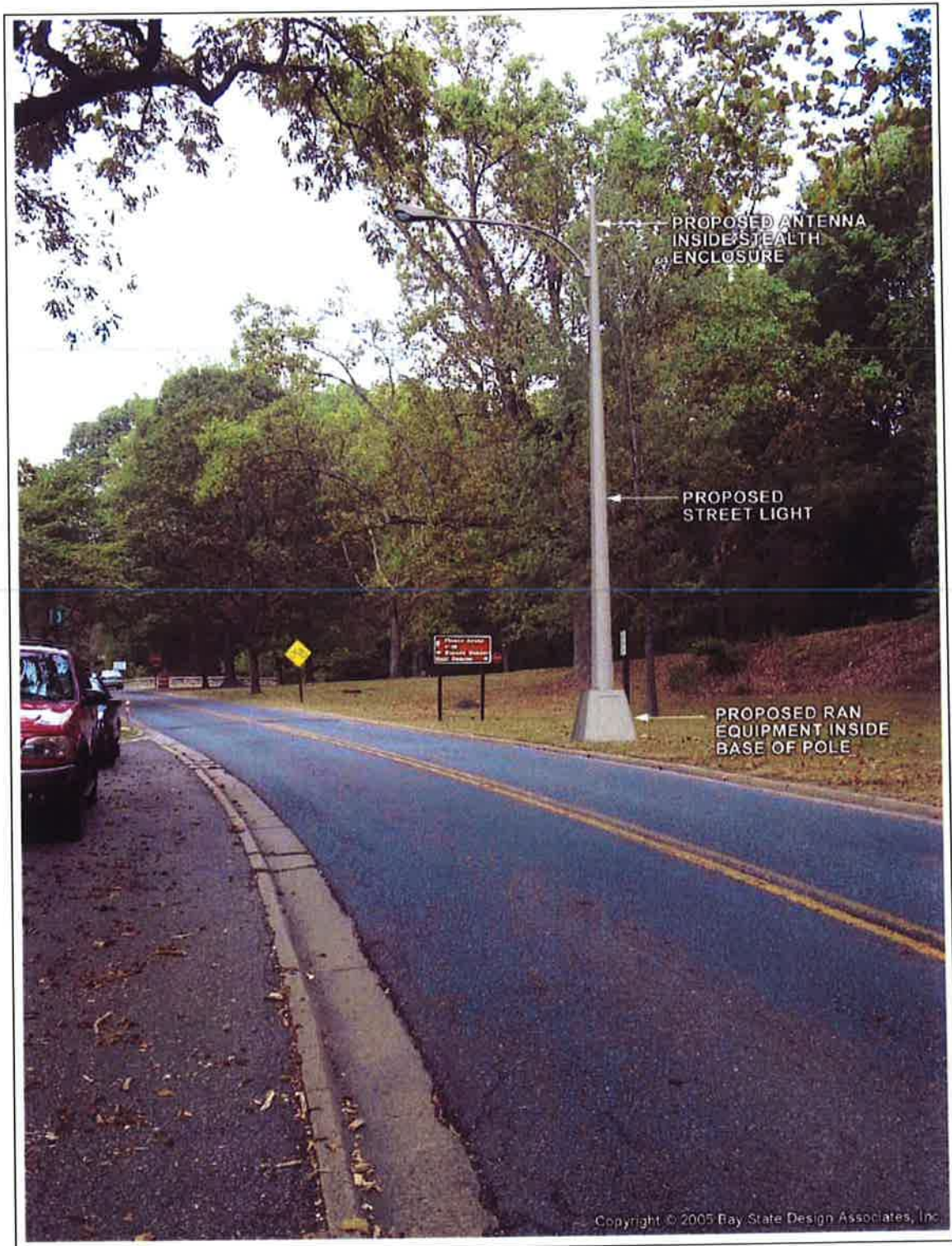


Figure 37: Crown Castle – Typical DAS Installation

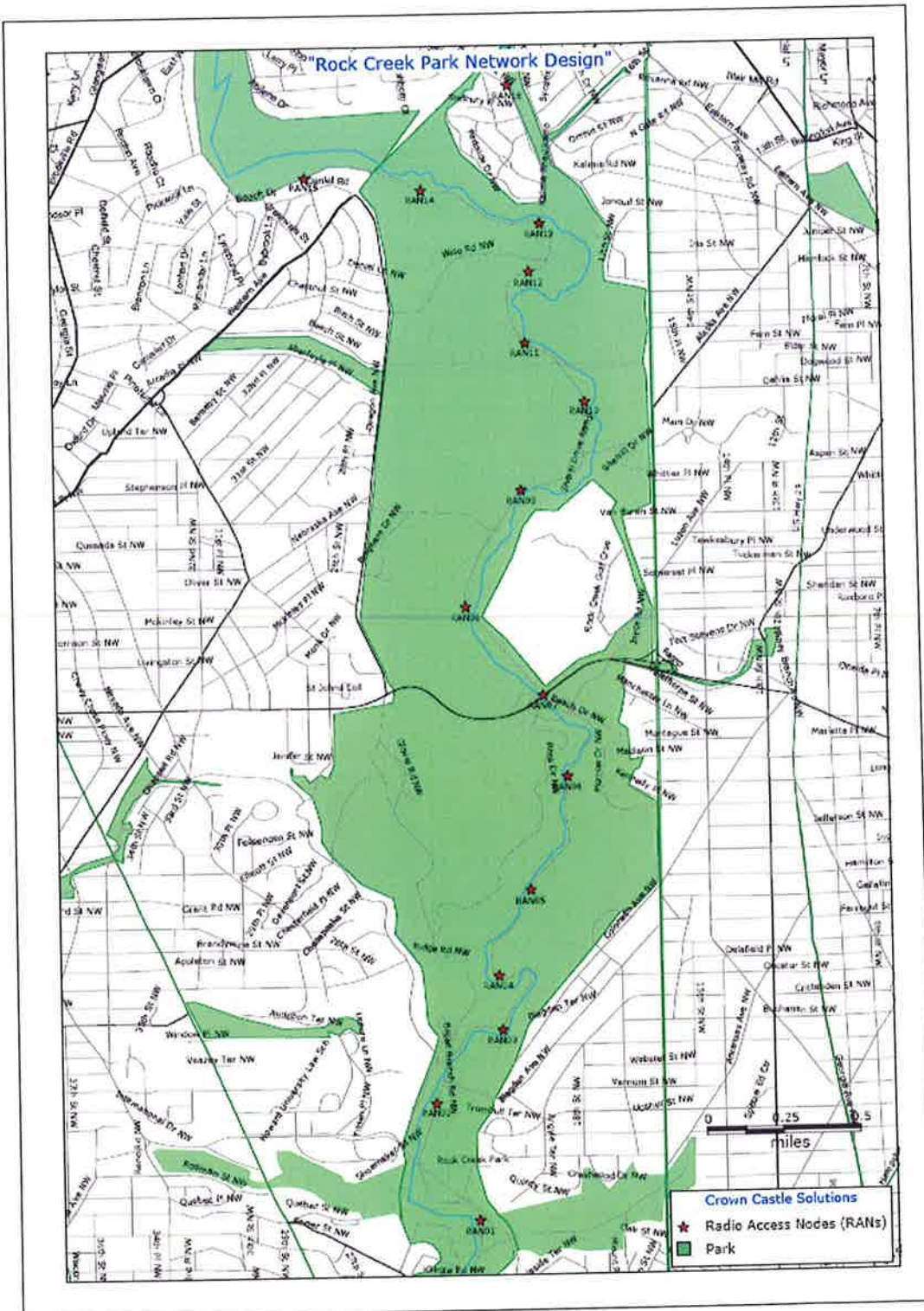


Figure 39: Crown Castle - Projected Locations of DAS Facilities